SHAI EVRA TO RECEIVE 2020 SASTRA RAMANUJAN PRIZE

The 2020 SASTRA Ramanujan Prize will be awarded to Dr. SHAI EVRA of Princeton University, USA, and the Hebrew University of Jerusalem, Israel. This annual prize is for outstanding contributions by individuals not exceeding the age of 32 in areas of mathematics influenced by Ramanujan in a broad sense. The age limit has been set at 32 because Ramanujan achieved so much in his brief life of 32 years. The prize is awarded annually at an International Conference in Number Theory during December 21-22, at SASTRA University in Kumbakonam (Ramanujan's hometown) in South India. Since the conference will not take place in December 2020, Dr. Evra will receive the prize in 2021 in Kumbakonam at a suitable date.

Shai Evra is an extraordinarily gifted mathematician whose research concerns locally symmetric spaces of arithmetic groups and their combinatoric, geometric, and topological structure. He employs deep results from representation theory and number theory pertaining to the Ramanujan and Langlands conjectures to establish expander-like properties.

Expander graphs are remarkable objects with connections to many parts of mathematics and computer science. Expanders are graphs which are highly connected; to separate them into disconnected pieces, one must remove a large number of edges. In the last decade, mathematicians have formulated the notion of expansion to higher-dimensional complexes. 2009 Abel Laureate Michael Gromov had introduced the notion of "geometric expansion" in terms of an affine overlapping property for simplicial complexes. He showed that complete complexes are such expanders and that a much stronger topological overlap property holds for them. He constructed several examples of higher dimensional expanders with unbounded degree and raised the question in a very influential 2010 paper in GAFA, whether bounded degree higher dimensional expanders exist. In a fundamental paper entitled "Finite quotients of Bruhat-Tits Buildings" that appeared in *Journal of Topology and Analysis* in 2015, Evra extended both the combinatorics and automorphic form theory (specifically the Generalized Ramanujan Conjectures) and generalized the construction of Gromov to other Bruhat-Tits buildings. However, the bounded degree problem of Gromov still remained unresolved. In the case of dimension 2, Gromov's question was answered in the affirmative by Kaufman, Kazhdan and Lubotzky in 2016 by showing that 2-dimensional skeleta of 3-dimensional Ramanujan complexes have the topological overlap property, but it was unclear how to carry this over to higher dimensions. Very recently, Shai joined forces with Tali Kaufmann and spectacularly solved this problem by showing that d-dimensional skeleta of $(d+1)$-dimensional Ramanujan complexes have the topological overlap property, and thus resolved Gromov's problem in all dimensions. This seminal paper which makes use of the work of Lafforgue on the Generalized Ramanujan Conjectures, is to appear in the *Journal of the AMS*. It is expected that the ideas developed in this paper will find many other important applications. Higher dimensional expansion is related to questions in the broader field of quantitative geometry and topology, as well as in coding theory and theoretical computer science (quantum error correcting codes).

Another major work of Evra (jointly with Ori Parzanchevski) concerns contruction of "Golden Gates" for three dimensional unitary groups. The classic work of Lubotzky, Phillips and Sarnak (1987, 88), provides topological generators for the orthogonal group $SO(3)$ such that for each ℓ, the set of ℓ-wise products of generators is distributed in an

almost optimal manner on the two dimensional and three dimensional sphere. Among other things, their proof makes use of the full strength of the Ramanujan Conjecture for $GL(2)$ as proved by Deligne. Recently this problem has received renewed interest due to its importance and relevance for quantum computing. The 3-sphere is isomorphic to $SU(2)$, with the group of logical gates acting on a single qubit. Considered as elements of $SU(2)$, the generators provided by Lubotzky-Phillips-Sarnak were given the name "Golden Gates" because the circuits constructed from these gates approximate any gate in an optimal manner. Ori Parzanchevski and Sarnak found Golden Gates for $PU(2)$ but whether one could achieve such miracles for higher dimensions was far from clear. In a recent impressive paper, Evra and Parzanchevski show that this is possible for $PU(3)$ with some striking examples, but this is demonstrated with very delicate analysis. They employ deep results of Ragowski and James Arthur (which had important consequences on the Generalized Ramanujan Conjectures) to show that the optimal covering features are still valid. The Golden Gates for $PU(2)$ and $PU(3)$ are basic building blocks for the construction of universal gate sets in quantum computation (much like "not" and "and" are universal one-bit and two-bit gates for building the classical logical circuits). It is to be noted that the Ramanujan Conjectures and their generalizations are a central piece of the outstanding work of Evra.

Sha Evra was born in Be'er Yaakov, Israel. He received his BSc, MSc, and PhD (2019) degrees from the Hebrew University in Jerusalem. His MSc and PhD advisor was Professor Alexander Lubotzky. He has been recognized with several prizes, most notably the Hebrew University Dean's Prize in 2010, the Perlman Prize in 2015, and the Nessyahu Prize in 2020. He spent the years 2018-20 as a Visiting Member at the Institute for Advanced Study, Princeton, and is spending this year (2020-21) at Princeton University, following which he will return to the Hebrew University permanently.

The 2020 SASTRA Ramanujan Prize Committee comprised: Krishnaswami Alladi - Chair (University of Florida), Willam Duke (University of California, Los Angeles), Kevin Ford (University of Illinois, Urbana-Champaign), Anne Schilling (University of California, Davis), Robert Tijdeman (Leiden University), Maryna Viazovska (Ecole Polytechnique, Lausanne), and Shouwu Zhang (Princeton University). Evra, who was the overwhelming choice of the Committee for the 2020 award, joins the illustrious group of winners of the SASTRA Ramanujan Prize.

Krishnaswami Alladi
Chair- SASTRA Ramanujan Prize Committee